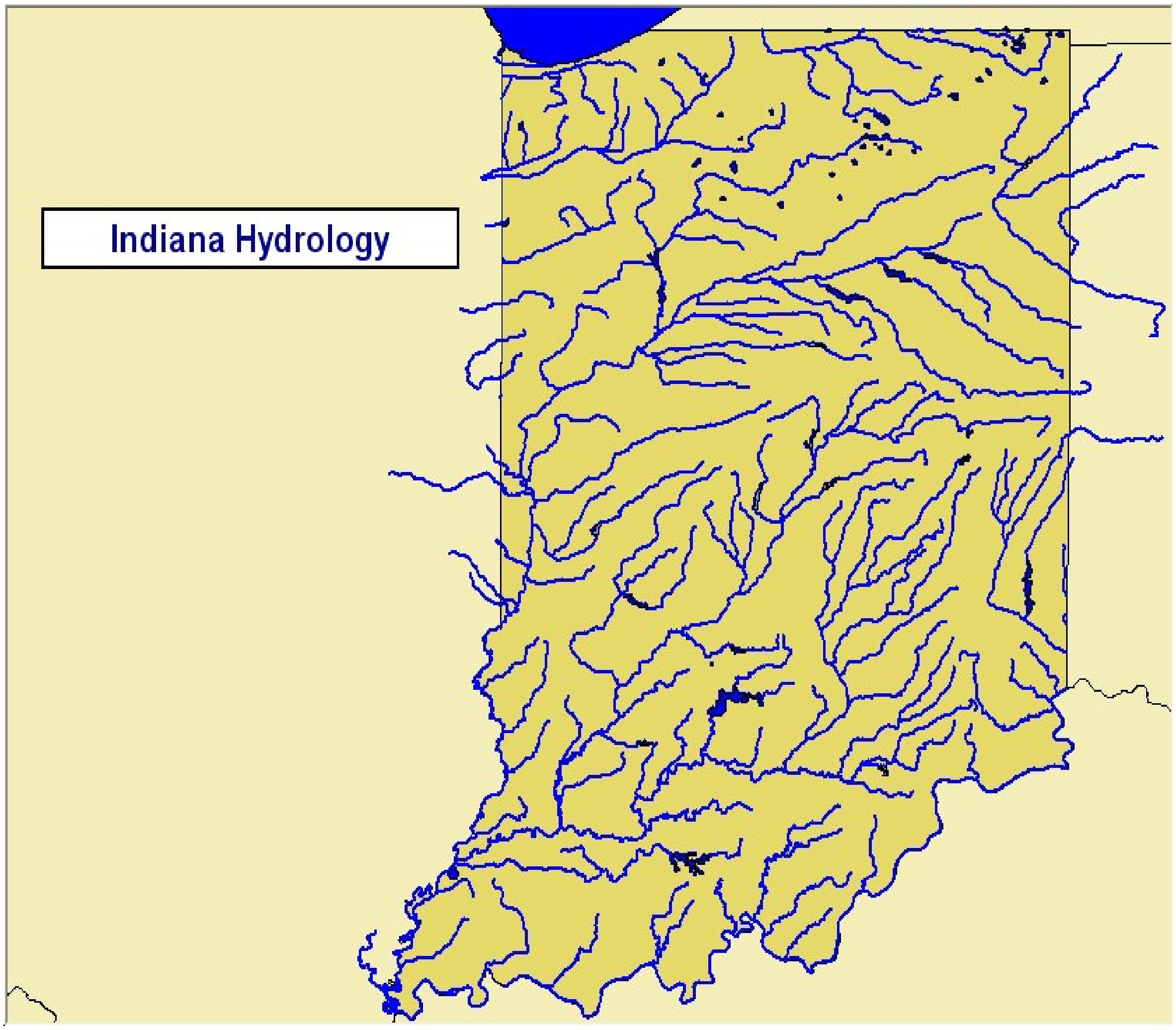
3.2 PROFILING HAZARDS

This section provides information on historical hazard occurrences for the State of Indiana in regards to the natural hazards identified in the risks profiled in the previous section – Flooding**, Tornadoes, Straight-Line Winds, Earthquake, and Winter Storms.



Flood History**

***The end result of dam and levee failure is flooding. Due to this fact there is not a separate profile for these hazards.*

Flooding is a recurrent problem in Indiana. Historically, the state has experienced annualized flooding along one or more of its rivers or streams. Its last major disaster declaration for flooding was in January 2008 in the northern third of the State. Almost all rivers in northern Indiana have experienced flooding in this disaster. As of March, 2008, 21 counties have been declared disaster areas.

The total financial impact of this disaster has not been finalized as the disaster is still ongoing (Indiana also received major flood disaster declarations in June of 2002, September 2003, June 2004, January 2005, October 2006 and December 2007). These floods are typical of flooding in Indiana and cover nearly all its counties. They are summarized below. These events illustrate that the same areas repeatedly flood and show the need for aggressive mitigation activities within their floodplains. (January 2005 flooding is summarized in Winter Storms Profile). The USGS provided IDHS with preliminary information as work was being completed on the plan. Because the information was received too late to be incorporated into the body of the document, we have attached it in appendix III for review.

January 2008
Tippecanoe River Flood

In fact, as this plan was being finalized, the State of Indiana is again experiencing flooding in the southern part of the state. The areas being impacted by this flood event are the White River basin, the Lost River basin, the Muscatatuck River basin, the Patoka River basin, Wabash River basin and Ohio River basin and on Pigeon Creek basin in Evansville several locations exceeded the 1% flood. At the height of the flooding in January of 2005, state-wide over two-thirds of counties were experiencing flooding. In fact, many of the rivers were experiencing record level flooding. Several levees were breached and more were threatened by river levels that exceeded records set during the statewide flooding of 1913.

Flood Vulnerability

Vulnerability is the susceptibility of population, human services, transportation, other infrastructure and the economy to damage. Vulnerability is essentially the linkage between hazard and loss. It is critical to current and future exposure analysis.

Based upon reported damages from historic floods, the following can be considered vulnerable to current and future damage and loss from flooding:

- Loss of human life.
- Livestock from drowning.
- Furnishings, equipment, personal property and basements.
- Roads and ditch lines from mud and rockslides.
- Roads and bridges due to washout, road surface and road bed failure.
- Rural water supplies (wells, springs and cisterns) due to contamination from surface water entering the supply source.
- Heat, water and electrical sources cut off due to rising water.
- Drainage from catch basins and retention ponds. If they cannot handle the volume of water, they cause back-up flooding.
- Homes are destroyed by deep, fast moving floods -- characteristics of the floodway portion of the flood plain.
- Municipal water and sewage treatment plants can become inoperable if levees and retaining walls are overtopped and/or if sediment basins are flooded.
- The supply of raw water from municipal water supply reservoirs and back up water supply reservoirs can be reduced or lost due to the failure of an impounding dam.
- In essential facilities, electrical panels and circuit breakers are often installed on interior walls below the 100-year flood level. This results in loss of power when the water rises to the level of the panels.
- Water can enter otherwise protected facilities through non-flood proofed mechanical and electrical rooms and through conduits.
- Bridges, culverts and stream crossings may be unable to handle the volume, causing backup onto roads and into residential and commercial structures.
- Backup of water can be caused or increased when automobile-bodies, refrigerators and other appliances that have been discarded into streambeds hinder the natural flow of water. Backup also occurs if drainage systems have not been properly maintained.
- Backup water can enter storm sewers and cause flooding in areas not threatened by stream flooding.
- Levees constructed by the Corps of Engineers are sometimes inadequate to hold back the volume of water resulting in the failure of the structure.
- Many developed areas have failed to provide for the excessive run-off caused by concrete and blacktop ground coverage.
- Detention basins, retaining walls and berms are designed to redirect water from vulnerable areas. Flooding often results when these protective measures are not in existence or have not been properly maintained.

INDIANA'S TOP TWENTY REPETITIVE LOSS COMMUNITIES As of December 31, 2007			
COMMUNITY	**# of Properties (mitigated and non-mitigated)**	**# of Properties (Non-mitigated)**	**Total # of Repetitive Losses** ***only includes non-mitigated properties***
1. City of Indianapolis	110	106	343
2. City of Fort Wayne	95	48	120
3. City of Kokomo	37	34	91
4. City of Evansville	34	28	83
5. Fulton County	33	19	57
6. Carroll County	25	25	73
7. Vanderburgh County	23	22	64
8. Clark County	22	22	69
9. Kosciusko County	19	9	22
10. City of Plymouth	18	14	41
11. City of Alexandria	16	16	54
12. Noble County	16	13	28
13. Howard County	15	12	34
14. City of Jeffersonville	14	14	50
15. Tippecanoe County	14	13	27
16. Allen County	13	10	32
17. Town of West Baden Springs	13	9	27
18. Town of Fishers	12	12	31
19. Town of Griffith	12	12	41
20. City of Marion	12	8	29
TOTALS	**553**	**446**	**1316**

Current & Future Exposure

Population Exposure - Due to the many rivers within the state (Ohio, Wabash, White, Maumee, St. Joseph, Tippecanoe, St. Mary, Kankakee, etc.), a large portion of Indiana's geographic area and population is vulnerable to flooding. The southern third of the state is most prone to repeated flooding. Hazards affecting the population result from a variety of flood actions, including:

- Overflow of land areas;
- Temporary backwater effects in smaller streams, sewers and drainage systems;
- Creation of unsanitary conditions;
- Deposition of materials in stream channels during flood recessions; and the rise of ground water coincident with increased stream flow.
- The tragic results of flooding includes the loss of life as well as damage and/or destruction of homes and businesses and their

contents, farms and farmland, public sector infrastructure and interruption of the economy. Counties declared disaster areas by the President in 1990, 1991, 1992, 1996 and 1997 and their 1990 census populations are found on the following page.

Human Services Exposure - Any human service agency with facilities and equipment in a floodplain is subject to damage and destruction of their facilities, inventory, emergency communications equipment and emergency vehicles during a flood. This would occur just as the agency faced a serious demand for service from patients and clients. **Reference CTASK GIS Assessment of Critical Infrastructure for Indiana Counties**

Transportation Exposure - The Interstate Highway System is constructed to elevations that accommodate 100-year flood levels. However, a number of state and county roads, as well as city streets will be under water. As the waters recede the same roads and streets will be covered with debris. Landslides will block many roads. Bridges and culverts might be undercut to the extent of being dangerous or closed. See INDOT bridge replacement table and INDOT facility replacement costs in Appendix III

Other Infrastructure Exposure - Floods can cause damage and destruction to the aboveground system components of all public utilities (water, electric, gas, sewer and telephone). Loss of water supply can result from the lack of electric power to operate the equipment and/or from damage and destruction of aboveground system components, such as water supply dams. The water system can also become contaminated from flood and backwaters.

Economic Exposure - The economic consequences of flood damage to individuals and businesses consists of lost wages due to temporarily or permanently closed businesses, destruction and damage to real and personal assets, loss of tax base, recovery costs to individuals, government and businesses and lost investments in destroyed assets.

Future exposure to floods will increase due to increases in population and development in those areas subject to repeated flooding. Mitigation projects and efforts will help reduce this exposure. It cannot be entirely eliminated.

Loss Estimation

Loss Potential

- For many locations across Indiana, the flood of 1913 remains the flood of record. Since then, considerable federal, state and local dollars have been spent to reduce future flood damage. Numerous flood control projects have been completed. In many areas floodplains are strictly controlled and individual property owners have implemented flood protection measures.

- While the flood threat has been reduced in many jurisdictions, particularly in the larger urban areas, it has not been eliminated.
- The August 1992 flood resulted in six counties being declared disaster areas. Estimates of damages were in excess of $ 2,395,500 for public assistance. No loss of life was attributed to this disaster.
- The September 1992 flood was the second declared flood disaster in the year for many of the damaged counties. The city of Alexandria in Madison County experienced the most damage. Estimates placed public damages at $5,375,166. The state and federal preliminary damage assessment estimated that a total of 148 homes were affected with over 81 of those either destroyed or substantially damaged. Franklin County suffered severe damages as a result of the storm. Damage Assessment Teams identified 49 locations where culverts and bridges had been washed out. Several landslides resulted from the intense rainfall and run-off. These slides blocked roads and diverted streams causing significant damage to roads, stream channels and structures located in the path of the water. There were no deaths as a result of this flood.

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- Following the flood of 2003, 78 of 92 of Indiana's counties were declared disaster areas. Two people lost th[illegible]ding. Approximately 1700 people were [illegible]antial damages estimated at over $13 million were documented from the Wild Cat Creek, Tippecanoe, Maumee, Wabash, White, and St. Mary Rivers as well as numerous creeks and ditch flooding.

See Hydrology Annex for detailed Indiana Watershed maps

- A "no action" response to flooding hazards will result in increased human suffering and property damage. Due to the magnitude of the hazard there must be a continuation of an aggressive program of flood mitigation coordinated with aggressive programs of public information and education, enforcement of floodplain management regulations, and response and recovery programs. A "no action" approach will result in greater repair and replacement expenditures when flooding does occur.

The losses resulting from the floods of 1991, 1992, 1997, 2002, 2003, 2004, 2007, and 2008 are excellent examples of the frequency of flooding, the risk to people, economic structure, and infrastructure caused by severe flooding in Indiana.

Appendix I includes the hydrology map of each county. The maps represent the current status of Indiana Flood plain maps. A few counties' maps have been converted to digital from paper and some have the Q3 maps. A very select few have new digitally drawn maps, but most have old paper maps. The counties where no form of digital map exists have only major rivers and lakes layered on the county maps. *The Department of Natural Resources retains a copy of all the current existing flood maps for the state and the accompanying Flood Insurance Stu*dy.

Expenditures By Flood Disaster					
Disaster #		**Public Assistance**	**Individual Assistance**	**Total (PA+IA)**	**Mitigation (7.5% of Total)**
DR - 1234		$4,901,470	0	$4,901,470	$735,221
DR – 1418		$6,165,581.61	$2,963,149.00	$9,128,731	$1,369,310
DR – 1476		$9,541,210.36	$13,364,570.04	$22,905,781	$3,435,867
DR – 1487*		0	$8,228,038.84	$8,228,038.84	$617,103
DR – 1520*		$7,678,597.90	$1,440,319.87	$9,118,918	$683,919
DR – 1573*		$18,618,691.99	$12,352,135.45	$30,970,828	$2,476,257
DR – 1612*		$2,477,205.63	$855,607.65	$3,332,814	$312,215
DR – 1662			$12,084,439	$12,084,439	$1,911,972
	Totals	**$49,382,757.49**	**$51,288,259.85**	**$98,004,183.24**	**$11,541,863**

* Mitigation dollars for 1487-1612 were 7.5% of total of PA and IA

Indiana Winter Weather Climatological Summary

Prepared for the Indiana Department of Homeland Security by Sally Pavlow, Logan Johnson and David Tucek of the National Weather Service in Indianapolis.

This summary includes excerpts from “A Winter Weather Climatology for Northern and Central Indiana” by Brian O’Hara, Julie Adolphson and Sally Pavlow.

Cool season meteorological phenomena have been recorded over Indiana for many decades. Throughout the nineteen nineties, all but two counties experienced winter storm disasters and emergencies. These events have had significant impact on the population of this area. This summary includes eight sections on winter weather events in Indiana.
Sections included:

1. Snow Storms
2. Snow Storm Source Regions
3. Lake Effect Snow
4. Extreme Cold
5. Ice Storms
6. Winter Storm Vulnerability
7. Current Exposure
8. Loss Estimation

1. Snow Storms
Indiana can experience snowfall during most years from November through March, especially in the lake effect snow belt in the northwestern part of the state. Snow has occurred as early as September and as late as May, although these events are rare. The first measurable snowfall of the season usually occurs by November 1st in northern Indiana and by mid-November in southern Indiana. Appreciable snowfall can occur sometimes even in April.
The winter season (December, January and February) snowfall average for South Bend is 57.9 inches. Fort Wayne, Indianapolis and Evansville receive less than half of South Bend’s yearly total. The substantially greater total at South

Bend is due mainly to lake effect snow which occurs during most winters across northwestern Indiana. Fort Wayne averages 25.8 inches of snowfall each winter, Indianapolis averages 27.5 inches and Evansville averages 13.7 inches. Figures 1 through 4 (found on the next two pages) lists the top 10 snowiest winters recorded at South Bend, Fort Wayne, Indianapolis and Evansville from 1949-50 to 2005-06.

The Blizzard of 1978 - Photo of downtown South Bend in January, 1978. 4-6 feet of snow fell in South Bend.

As can be seen in the figures, the winters of 1977-78 and 1981-82 were the snowiest at three of the locations. Four significant snow storms affected northern and central Indiana during the winter of 1977-78. The snowstorm on 25-26 January 1978 was of historic proportions with 10 inches to over 20 inches of snowfall occurring across the region. On 29 January 1977, the National Weather Service issued a Blizzard Warning. The storm that followed brought 50 mph winds and sub-zero temperatures. The blowing snow buried vehicles and the landscape under 20 foot drifts. The intensity of the storm was heightened by the natural gas shortage the state was experiencing due to the nearly 30 days of sub-zero temperatures which also froze the Ohio River. Although the northern two thirds of the state were hardest hit; deep, drifting snow made state-wide travel difficult at best. Drifting snow stranded an Amtrak train traveling to Chicago from Florida. Nine people died as a result of the storm. The two largest lake effect snow events at South Bend (since 1950) also occurred during the winter of 1977-78. One event, in late-November 1977, deposited over 24 inches of snow at South Bend. A second lake effect snow event in early January 1978 generated over 23 inches of snowfall.

Six large weather systems affected northern and central Indiana during the 1981-82 snowfall season, resulting in the snowiest winter at both Fort Wayne and Indianapolis, and the second snowiest at South Bend. Four significant lake effect snow events also occurred during this winter which contributed to the snowfall total at South Bend.

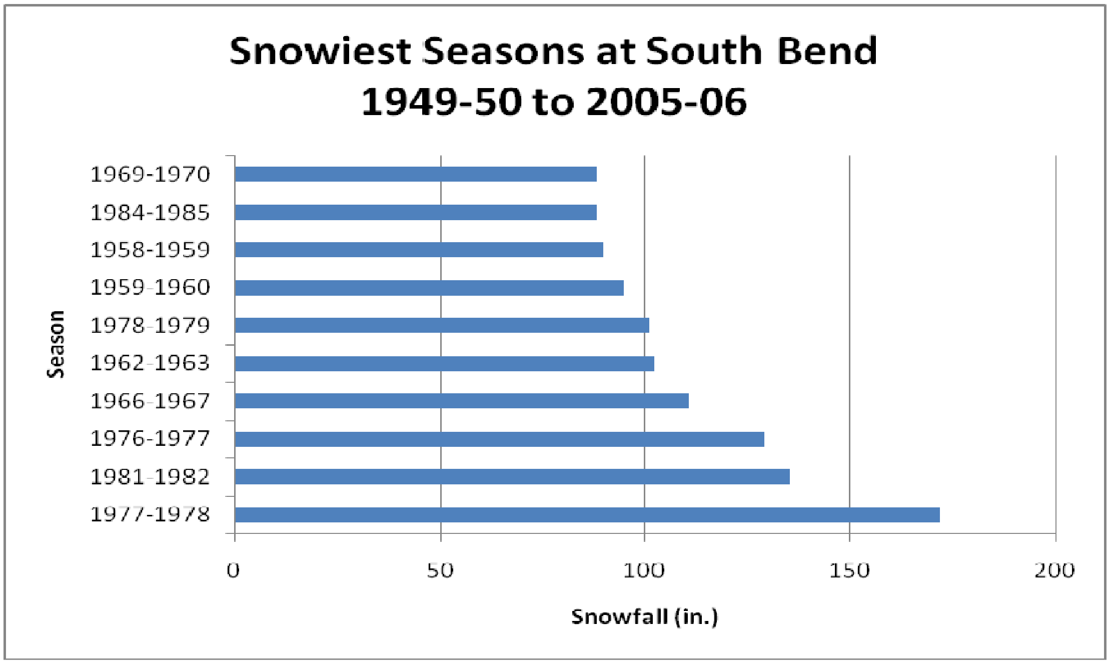


Figure 1

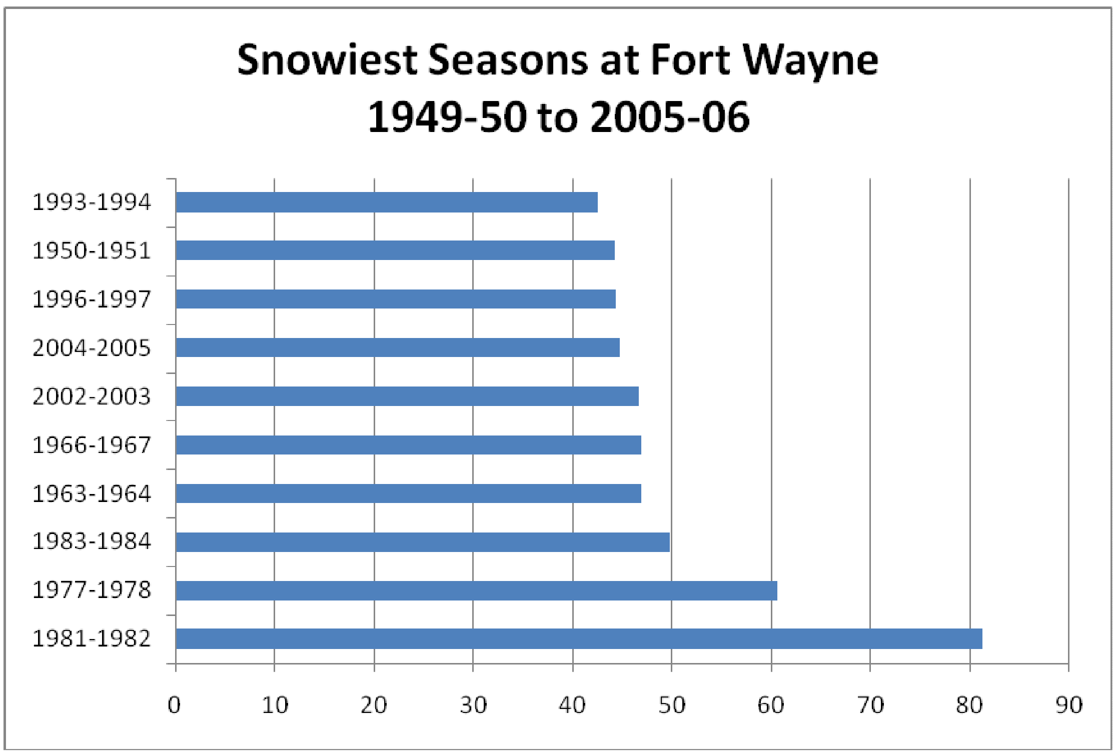


Figure 2

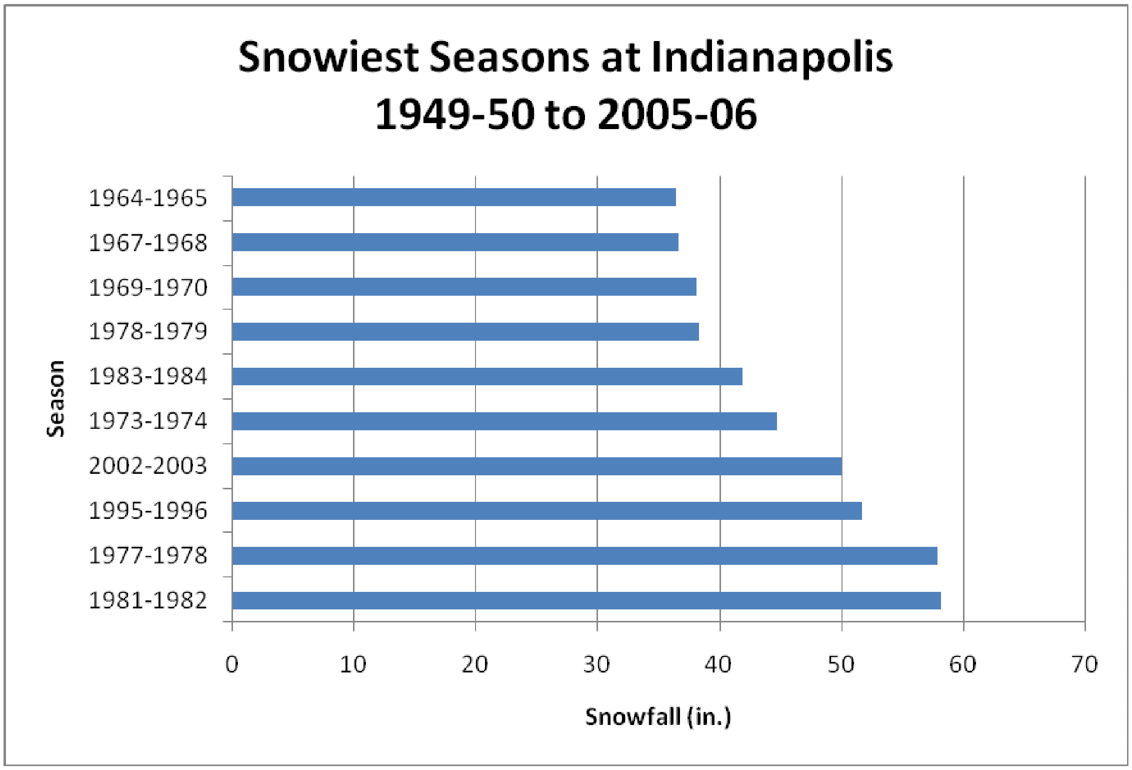


Figure 3

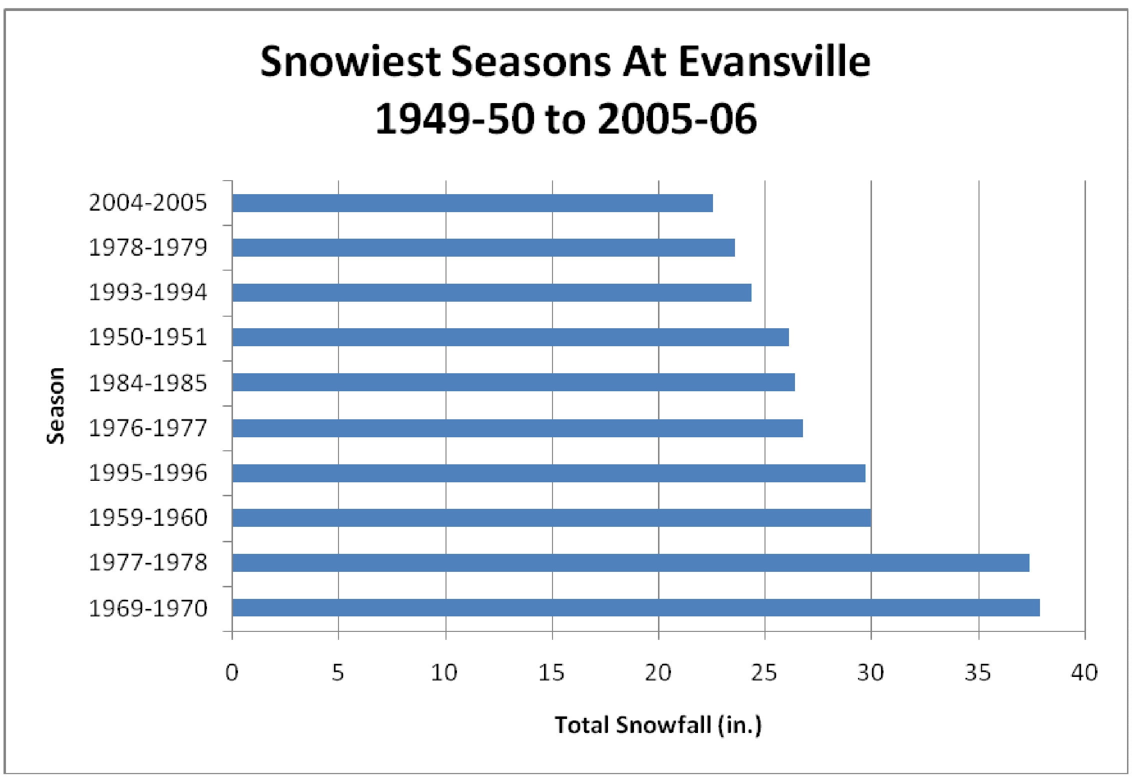


Figure 4

Even though snowfall can occur throughout the late-autumn to early-spring months, it is typically heavy snow that causes the most problems for residents of

Indiana. The National Weather Service defines “heavy snow” as snowfall which accumulates to depths of 4 inches or more in 12 hours, or 6 inches or more in 24 hours. In the lake effect snow belts these definitions are adjusted upward to 6 inches or more in 12 hours and 8 inches or more in 24 hours.
Heavy snow causes many problems for the public. Snowfall rates can exceed an inch per hour. As these systems intensify, wind speeds can approach hurricane force (74 mph). The blowing and drifting snow that results can paralyze a region. Automobiles are stranded on highways and peoples' lives are at risk in the absence of adequate shelter. With roads impassable, travel may be restricted for significant periods.

To further compound risks, cold air moving south behind the retreating low pressure area can cause temperatures to plummet. As the arctic high pressure area behind the low builds into the region temperatures can fall to 20 to 30 degrees below normal. A cold air mass can stay over the region for up to a week, until the next weather system moves in. These conditions can tax utility systems that are already working at peak output.

The weight of the snow itself can also be a problem, especially if the snow has a high water content. Tremendous weight of snow from significant storms can cause structures to collapse. Tree branches, especially on fully-leaved trees, can easily break under the weight of heavy snow. For example, if a snow cover of 12 inches has a water equivalent of 1.0 inch of water it would weigh 5.2 pounds per square foot. Additional snowfall would continue to increase this weight and structures could eventually become stressed. Flat roofs are especially susceptible to this problem but sloping roofs, especially if the structural components are weak, can also be damaged.

On average, Indiana experiences significant snow events once or twice per winter. However, the largest snowstorms are the ones that cause the most damage and inconvenience to the public and tend to be the ones that are the most easily remembered. A few in fact may be remembered for a lifetime.

2. Snow Storm Source Regions

Local research has revealed that strong low pressure systems affecting central and northern Indiana generally come from eight source regions. These regions, in order of their importance, are (a) the central Rocky Mountains, (b) the southern Rocky Mountains, (c) Alberta, (d) the Pacific Ocean, (e) the Texas/Oklahoma panhandle, (f) the Gulf of Mexico, (g) the Atlantic Coast, and (h) the Great Lakes. A review of the data indicates that nearly half of the largest snowstorms to affect the region originated in the central and southern Rockies. Of the 25 synoptic events that deposited the most snowfall at Indianapolis, Fort Wayne, and South Bend, six systems formed over the central Rockies and six originated over the southern Rockies. The trajectories of these snowstorms resulted in the advection of copious moisture from the Gulf of Mexico, leading to significant snowfall totals.

The most memorable system to affect central and northern Indiana during the last fifty years was the incredible snowstorm of 25-26 January 1978. This system originated over the southern Rockies. It moved south to near Brownsville, Texas, then out over the Gulf, and north through the Tennessee valley. It then merged with another system from the northern plains. This combined system then moved across Lake Erie, setting low pressure records as it moved north through the Ohio Valley into eastern Canada. Over 21 inches of snow fell at South Bend, over 10 inches at Fort Wayne, and over 15 inches at Indianapolis during this two day period. This combination of events produced what could be considered a “once-in-a-lifetime” snowstorm.

Eight other southern or central Rockies systems produced storm total snowfall of at least 10 inches in at least one location at South Bend, Ft. Wayne or Indianapolis. A system during the third week of December 1973 originated over the central Rockies. This system deposited over a foot of snow across central and northern Indiana.

Five Pacific systems made the list of top twenty most powerful systems to affect the study area. One of these systems was ranked number 4. This snowstorm was responsible for 11.5 inches of snow in South Bend and 12.5 inches of snow in Indianapolis on 24-25 February 1965. This system, however, took an interesting track. It moved across Idaho and Wyoming on the 22nd and into the southern Rockies on the 23rd. It then rounded the Big Bend region of Texas, moved out into the Gulf, and then northeast along the Appalachian Mountains to the eastern Great Lakes. This system could have been considered a Gulf or southern Rockies low except that its circulation could be followed all the way from the Pacific.

This table gives the total number of systems originating in each source region and indicates the months during which these systems affected central and northern Indiana during the period of this study. (The 31 December 1957 - 1 January 1958 event was listed in the December totals since the low formed during that month.

Temporal Distribution of Systems from Various Source Regions								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Central Rockies		4	7	5	1	4	3	22
Southern Rockies		1	3	7	7	4		24
Alberta		1	4	5	5	1	1	17
Pacific			3	4	2			9
Panhandle			3	2	2	1		8
Gulf		1	1	1	2			5
Atlantic Coast	1	1						2
Great Lakes			1					1
Total	1	8	22	24	19	10	4	88

a) Central Rockies Lows -The largest number of low pressure systems (24) that affected central and northern Indiana during the fifty years of the study were lows that originated in the central Rocky Mountains. For this study the central Rockies is defined as the area from northern Idaho and Montana south to southern Nevada, Utah, and Colorado. These lows tend to move southeast into the central and southern Plains before curving and moving through the Ohio valley and into the northeastern U.S. Figure 4 shows the tracks of central Rockies lows from the 1950s through the 1970s. Figure 5 shows the tracks from the 1980s through the 1990s.

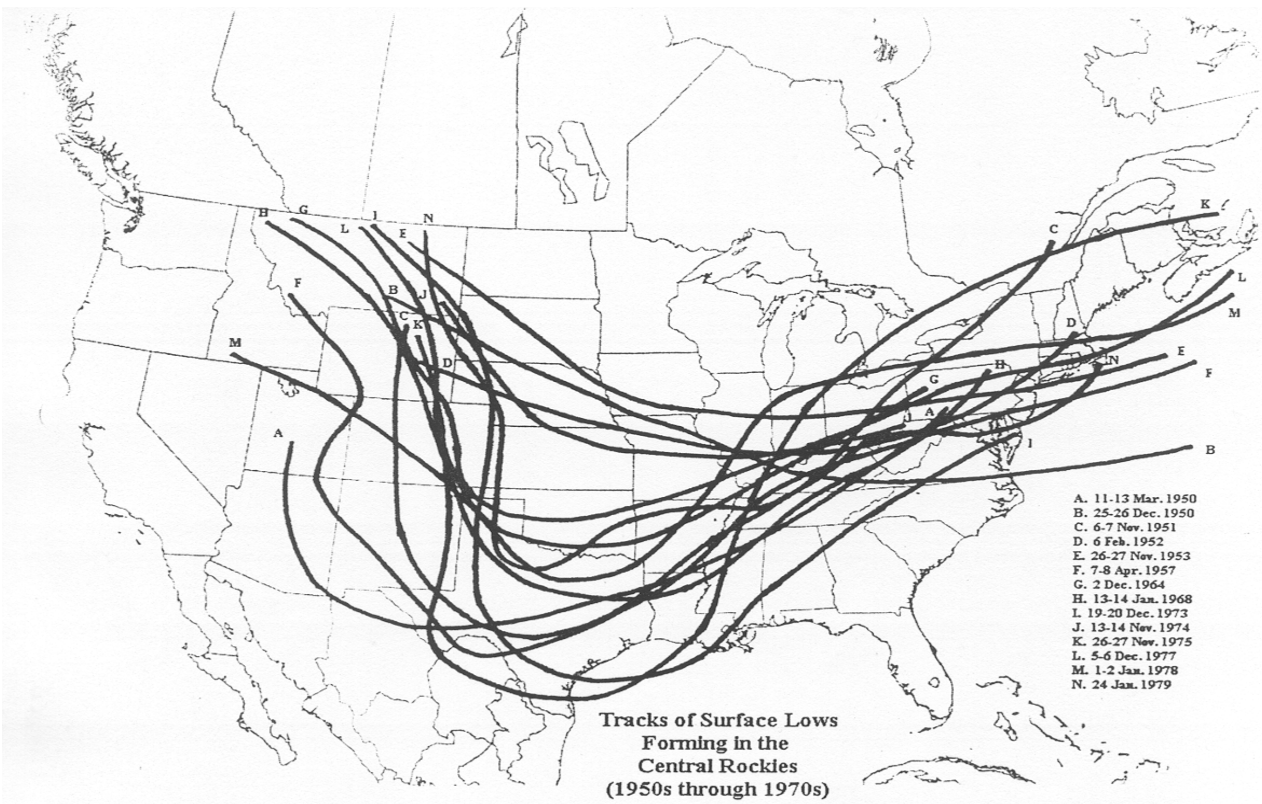


Figure 4 - Tracks of Surface Lows forming in the Central Rockies 1950s through 1970s

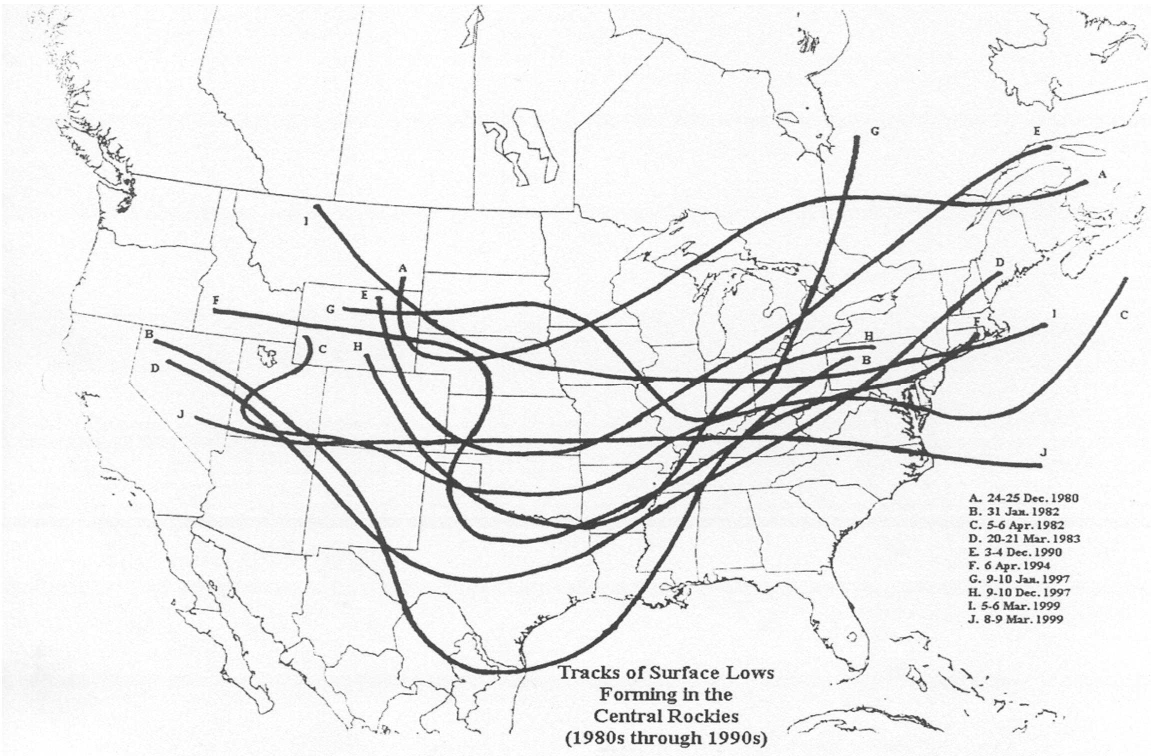


Figure 5- Tracks of Surface Lows forming in the Central Rockies 1980s through 1990s

b) Southern Rockies lows.

In this study the southern Rockies is defined as the area from northern Arizona and New Mexico south into northern Mexico. Twenty-two lows originated in this region. These systems typically followed a curved trajectory through southern Texas into the lower Mississippi valley, and then along the western edge of the Appalachian Mountains into the northeastern U.S. Like central Rockies lows, these systems can deposit large snowfall amounts over the Great Lakes as they pull in Gulf moisture on their trek into the northeastern U.S. These strong systems average approximately one every other year.

The tracks of these systems are almost identical to those of central Rockies lows. One difference is that the source region of central Rockies lows is farther north. Another difference is that, in this study of strong systems, central Rockies lows tended to occur earlier in the season (from November through January). As the storm tracks migrated farther south during the winter, lows tended to form over the southern Rockies later in the season (from January through March). Over half of the 88 systems identified in this study originated in either the central or southern Rockies. Figure 6 shows the tracks of these systems from the 1950s through the 1970s. Figure 7 shows the tracks for systems from the 1980s through the 1990s.

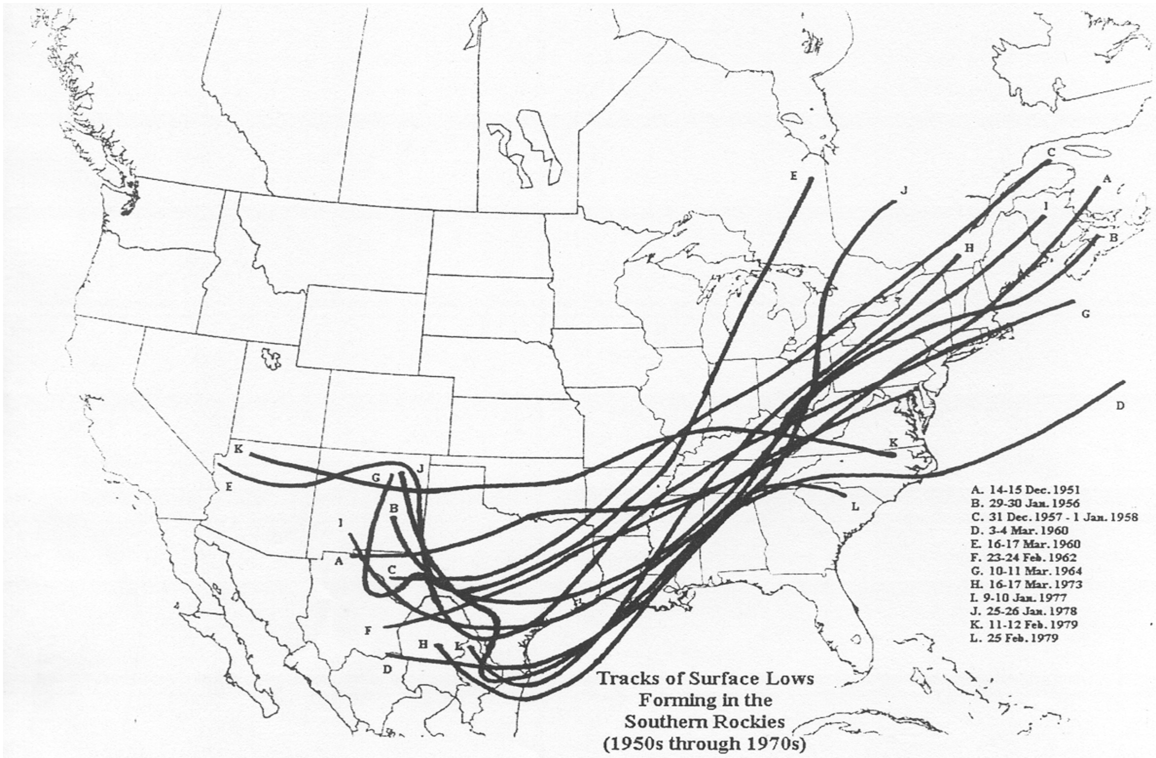


Figure 6 Tracks of Surface Lows forming in the Southern Rockies 1950s through 1970s

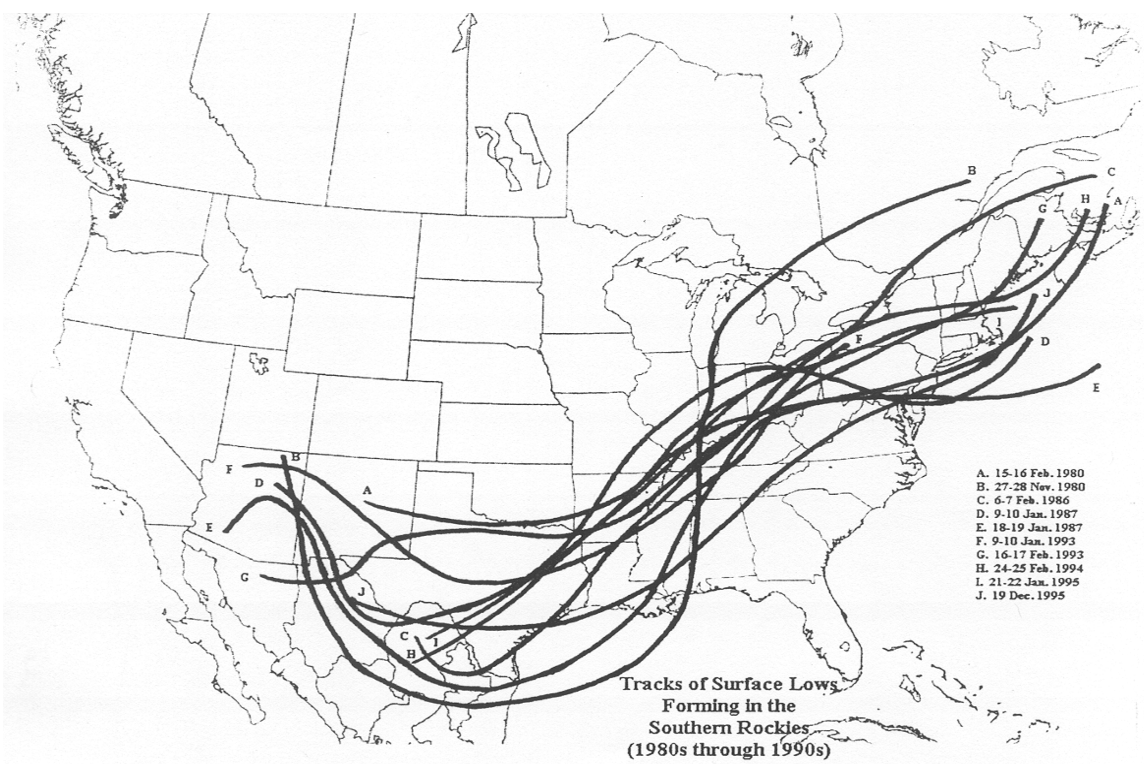


Figure 7 Tracks of Surface Lows forming in the Southern Rockies 1980s through 1990s

c) Alberta lows.

Alberta lows ("Alberta Clippers") affect the Great Lakes region fairly often each winter. These systems originate in the Canadian Rockies in or near the province of Alberta (hence their name) and, often aided by a strong polar jet stream, quickly move across the northern Great Plains. Moisture is often already in place over the Great Lakes region before these systems move in. The strong upper-level dynamics and cold air aloft help to make these systems quite potent as they move out of the Plains. During the 50 years of this study 17 systems were classified as Alberta Lows. Figure 8 shows the tracks of Alberta lows from the 1950s through the 1990s.

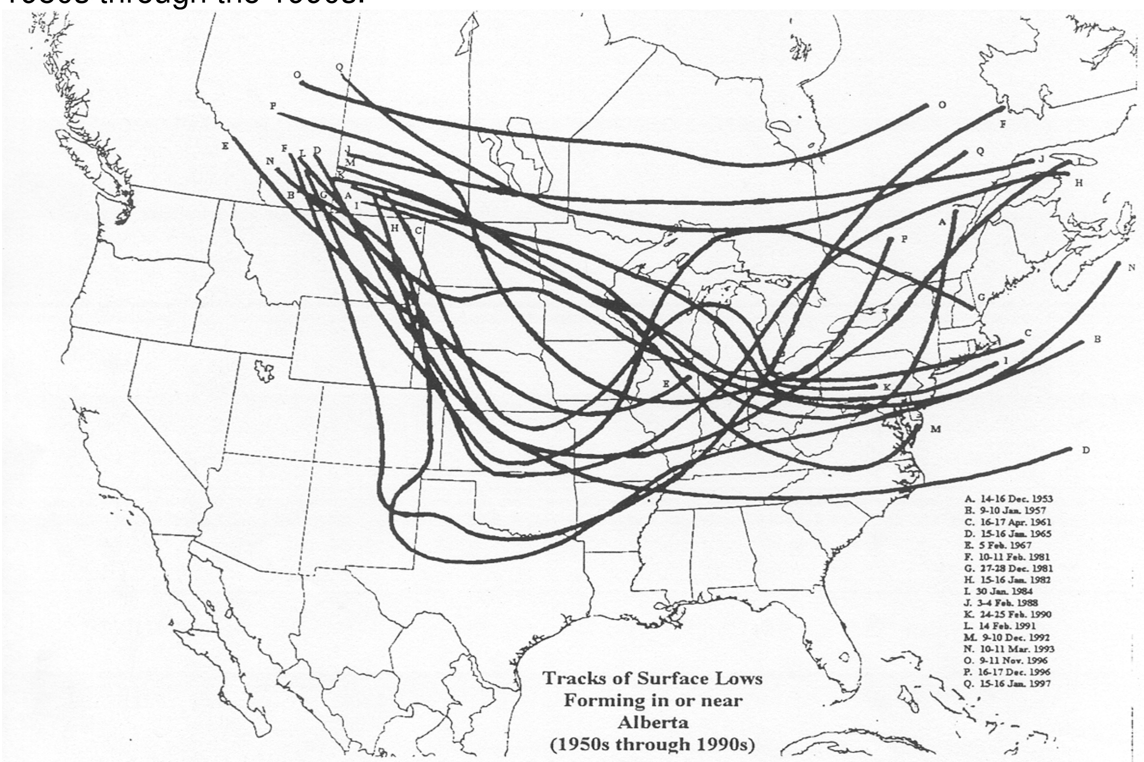


Figure 8- Tracks of Surface Lows forming in or near Alberta 1950s through 1990s

3. Lake Effect Snow

Lake effect snow (LES) is a fairly common occurrence downwind of the Great Lakes, and a substantial portion of seasonal snowfall can result from lake effect snow events. The impact of lake effect snowfall can be seen when comparing the annual snowfall totals of South Bend and Fort Wayne. South Bend receives an average of 75.1 inches of snow (1971-2000 thirty-year normals), La Porte sees 63.1 inches and Valparaiso receives 40.8 inches. Farther away from the lake by contrast, Fort Wayne records an average of 34.4 inches.

Typically, the surface of Lake Michigan does not completely freeze during the winter. Therefore, lake effect snow can occur throughout the winter. However, over northern Indiana, lake effect snow is most common from late-autumn through mid-winter when the lake water is substantially warmer than the surrounding land.

In late-summer the average land surface temperature decreases. The temperature of the lake surface typically reaches its maximum a month or two later. Throughout the autumn and early-winter the land surface cools at a faster rate than does the lake surface. The land remains cooler than the water throughout the autumn and winter. This "unstable" season lasts from around late-August until middle- to late-March. The difference between the land temperature and lake temperature reaches its maximum in late-December to early-January.

A typical lake effect snow scenario involves the passage of a surface low pressure area or a cold front with northwesterly winds behind the system then blowing across the lake. As this cold air mass moves across the relatively warm lake surface the lower part of the air mass is warmed. The air mass also picks up moisture from the surface of the lake. This moist unstable air mass can produce clouds downwind of the lake. Vertical directional wind shear, along with orographic[1] lift and frictional effects at the lakeshore, can then help to produce snow showers.

[1]Orographic lift occurs when an air mass is forced from a low elevation to a higher elevation as it moves over rising terrain. As the air mass gains altitude it expands and cools adiabatically. This cooler air cannot hold the moisture as well as warm air can, which effectively raises the relative humidity to 100%, creating clouds and frequent precipitation.
From Wikipedia, the free encyclopedia

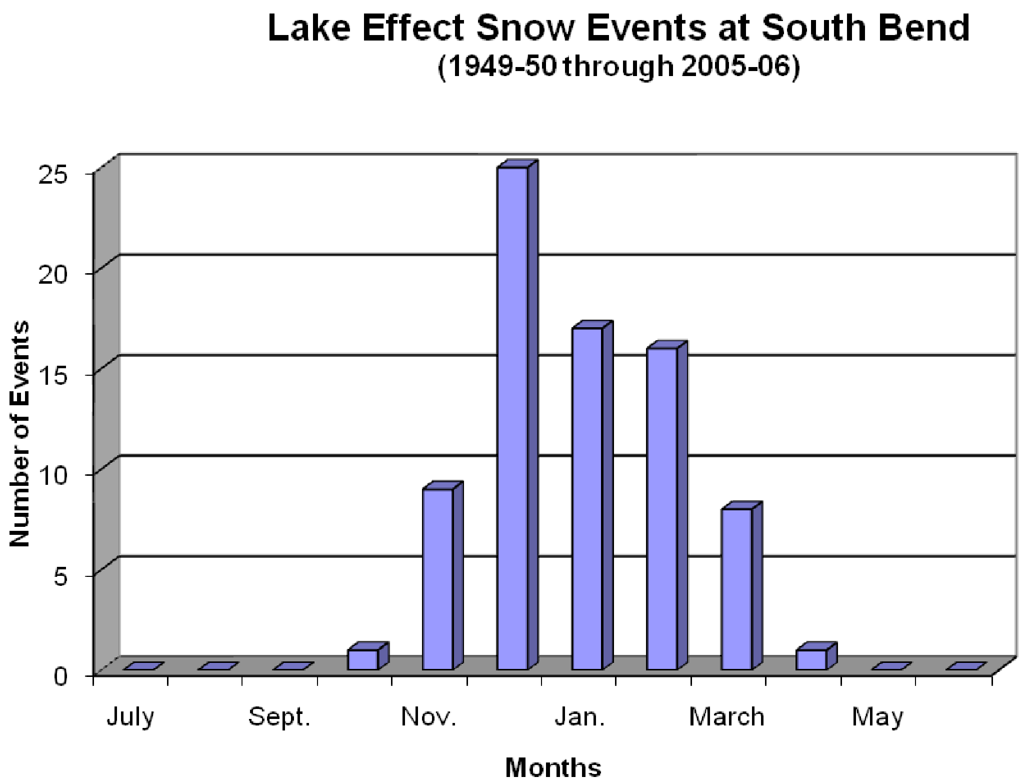


Figure 10

The following table lists the 20 greatest lake effect events experienced in northern Indiana since 1949-50.

Greatest Lake Effect Snow Events
in Northern Indiana
(1949-50 through 1998-99)

Event	South Bend Snowfall (in.)	Event	South Bend Snowfall (in.)
1. 25-27 Nov. 1977	24.3	11. 3-4 Nov. 1976	12.2
2. 8-10 Jan. 1978	23.4	12. 10-12 Feb. 1955	12.1
3. 22-24 Feb. 1993	20.1	7-8 Feb. 1995	12.1
4. 9-11 Dec. 1962	19.8	14. 15-17 Feb. 1958	11.5
5. 18-19 Dec. 1981	16.3	15 Feb. 1991	11.5
6. 15-16 Jan. 1959	16.1	16. 20-21 Dec. 1976	11.1
7. 9-11 Mar. 1998	15.8	17. 24-25 Feb. 1967	11.0
8. 2-3 Dec. 1989	13.1	18. 22-23 Jan. 1987	10.8
9. 26-27 Jan. 1986	12.9	19. 19 Dec. 1954	10.3
10. 9-10 Jan. 1982	12.3	20. 20-21 Jan. 1961	10.2

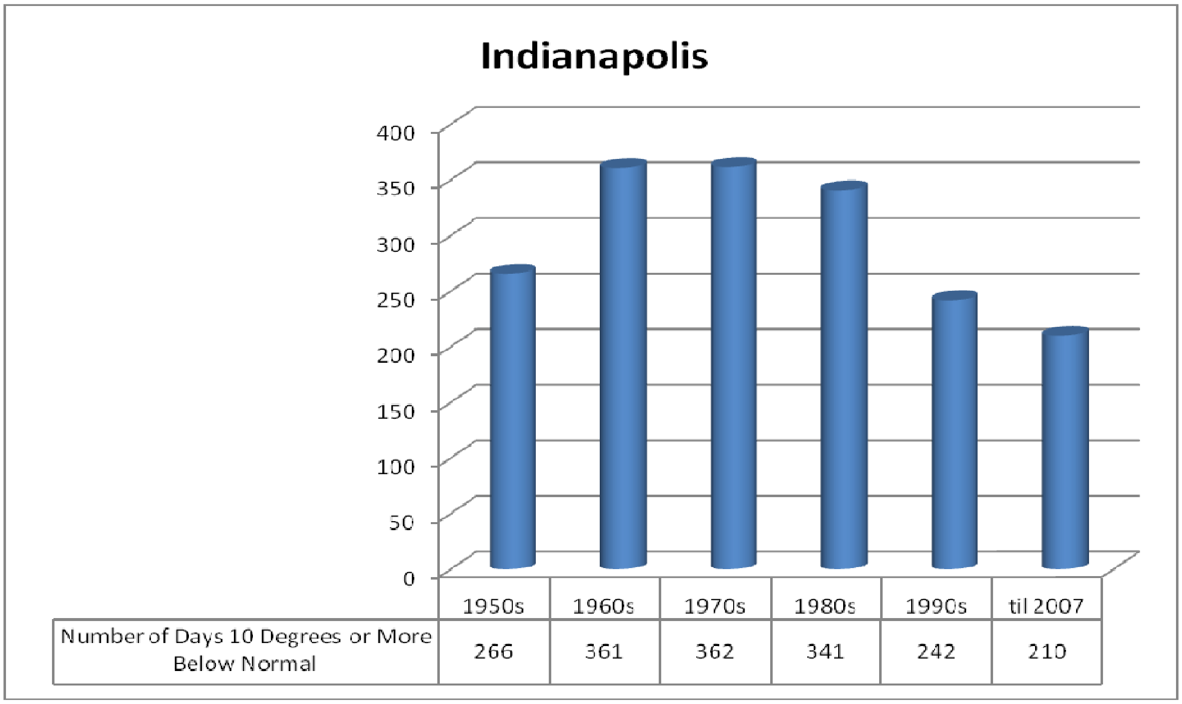
4. Extreme Cold

Extended outbreaks of temperatures well below normal are not only a nuisance but can be a public health hazard. Hypothermia and frostbite are the most common cold weather related health hazards. Hypothermia is defined as a lowering of the core body temperature to 95^{O}F (32^{O}C). According to the Centers for Disease Control and Prevention (CDC), from 1979 to 1992 a total of 10,550 people in the United States died from hypothermia. Locally, from 1979 to 1998, only five Indiana counties reported deaths due to hypothermia for a total of 9 deaths statewide for the period of record. Not surprisingly, Marion County (highest population) was the leader with 5 deaths for the period of record.

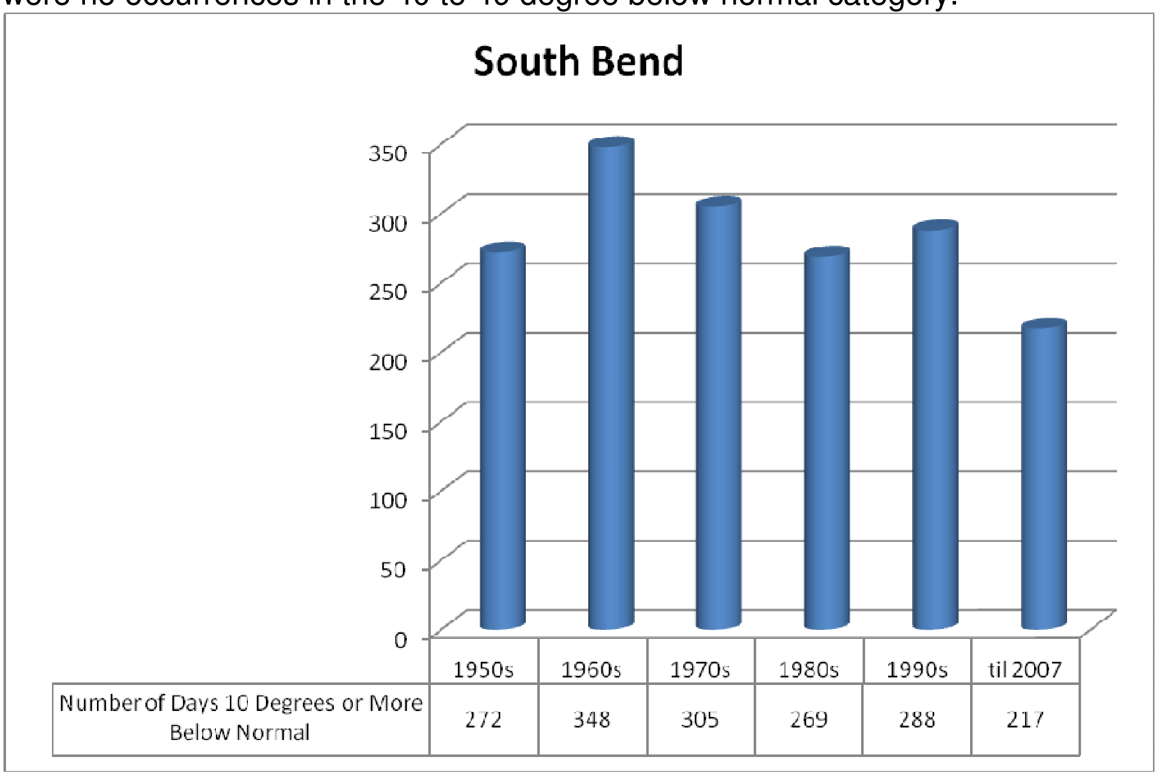
Frostbite is defined as damage to the skin and underlying tissues caused by extreme cold. Although death from frostbite does not occur, injury to extremities can be serious enough to require amputation. Other indirect health impacts from extreme cold are the increase in influenza, pneumonia, and other respiratory illnesses.

An analysis of cold outbreaks at South Bend, Fort Wayne, and Indianapolis was conducted. The period studied was from 1950 to 2007 during the months of October, November, December, January, February, March, and April. A cold outbreak was defined as daily average temperatures anywhere from 10^{O}F below normal for one day or more, on down to 49^{O}F below normal. The data were further divided into groups of 10 to 19 degrees below normal for 1 day or longer, 20 to 29 degrees below normal for 1 day or longer, 30 to 39 degrees below normal for 1 day or longer, and 40 to 49 degrees below normal for 1 day or longer. No daily average temperature colder than 49 degrees below normal was observed. The 10 to 19 degrees below normal category was the most frequent occurrence at all sites.

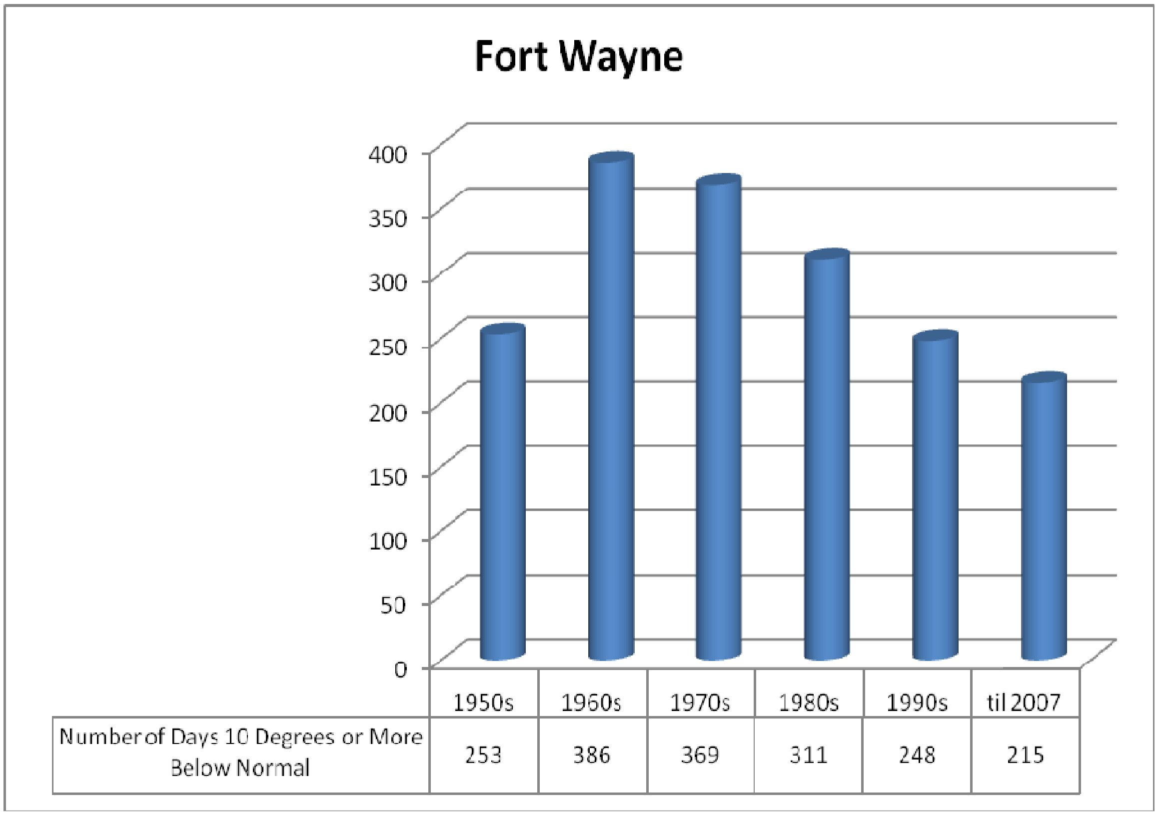
For Indianapolis, the 1970s barely have the most occurrences of below normal temperatures compared to other decades in the study. The 1990s have the fewest occurrences of below normal temperatures (for a full decade) compared to other decades. There were four occurrences of daily average temperatures 40 to 49 degrees below normal - the most of the three stations studied.



For South Bend, the 1960s have the most occurrences of below normal temperatures compared to other decades. The 1980s have the fewest occurrences of below normal temperatures compared to other decades. There were no occurrences in the 40 to 49 degree below normal category.



For Fort Wayne, the 1960s have the most occurrences of below normal temperatures compared to other decades. The 1990s have the fewest occurrences of below normal temperatures compared to other decades. There were two occurrences of daily average temperatures 40 to 49 degrees below normal.



5. Ice Storms

Ice storms can have some of the biggest impacts of any winter storm because of the widespread tree and power line damage that occurs along with the significant impact on ground travel. Although ice storms can occur at anytime during the winter season they tend to be more prevalent in January and February because frozen surface conditions are necessary, and such conditions typically take a while to develop during the season. Winter storms producing freezing rain often originate from the southern states and move into the Ohio Valley region on the heels of an arctic air mass in place over the Great Lakes. Storms producing freezing rain occur several times each winter in Indiana, though most of the time, these only cause surface transportation problems with no significant tree or power line damage. Records to 1948 indicate that 10 “damaging” ice storms have occurred in Indiana, averaging about once each decade, causing significant tree and power line damage as well as significant transportation problems. Freezing rain accumulations tend to parallel the track of a storm system and occur in a band ranging from 25 to 100 miles wide though the core of most significant ice damage is usually less than 50 miles wide. Since the ice zone parallels the storm systems track, the area impacted often runs from the west side of the state to the Ohio state line. Studies have shown that damaging conditions occur when ice thickness reaches 0.25". From observations in Indiana, significant damage is often associated with ice accumulations exceeding a half inch. When strong winds accompany the freezing rain, ice accumulations need not be as thick to cause damage, owing to the added stresses and forces applied to objects as they sway in the wind.

In February 1990, an ice storm impacted many parts of north and central Indiana. Ice accumulations from one half inch to over one inch were common. More than 20,000 people lost power, some for over a week. Cleanup costs were around $2 million dollars.

In January 2005, heavy freezing rain occurred over parts of the northern third of Indiana. Widespread half-inch ice accumulations were reported, with isolated one inch or greater amounts, crippling communities for as much as several days to over one week while cleanup lasted for more than a month. Electricity was knocked out for as many as 150,000 homes in areas affected by the storm. Shelters were opened by the Red Cross and other organizations across the area, with more than 1,000 residents taking advantage of shelters in east central Indiana alone. States of emergency were declared in several counties, and hospitals and other emergency services were forced to go to backup power. Nearly $75 millions of dollars in damage were done to trees, power lines, and structures and the associated cleanup work.

Southern Indiana is not immune to ice storms, having been involved in three damaging ice storms since 1948, and numerous freezing rain events of lesser impact. In January 2004, an ice storm brought one quarter to one half inch of ice to southwest Indiana. Roads were dangerous and locally impassable. Hundreds of accidents were reported, including jackknifed tractor trailers. Scattered power outages impacted more than 15,000 people. Evansville Regional Airport was closed for about three hours. The volume of accident calls was so great that towing companies were unable to keep up with the demand for help. Schools were cancelled on the day following the ice storm.

Frozen precipitation does not have to be heavy to cause significant travel issues. Freezing drizzle often causes some of the most dangerous surface transportation problems because the precipitation freezes to a nearly invisible layer on surfaces, commonly referred to as black ice. In February 2007, freezing drizzle caused no significant tree or power line damage but snarled traffic across most of central and southern Indiana. A semi trailer which jack knifed on interstate 65 shutting down traffic for nearly an entire day was typical of the impacts of ice along Interstate highways.

6. Winter Storm Vulnerability

Most vulnerable to the effects of a winter storm are the economic aspects of a community. This is, for the most part, a type of damage, which is difficult to quantify. These losses are subjective. Industry, retail, trades, etc. are dependent not only on the constant supply of goods, but also on people to build, manufacture, and purchase goods and services. All are dependent upon the transportation and utility systems within the city, county, state, and nation. Some will recover when the people and goods are able to move around, but at increased cost due to overtime, spoilage, and increased material costs. These losses are not losses that are normally considered or funded through government disaster assistance. We can figure the cost of replacing transformers, wire, communication towers, etc. It is more difficult to measure the loss of business revenues due to loss of telephone, communications, or the absence of employees.

7. Current Exposure

Population Exposure - Historical information indicates that the entire state is at risk to winter storms. Persons who are isolated in the best of weather conditions are also the ones in the greatest danger. They are more reliant upon the roads and vehicular travel for access to needed supplies. Lack of communication due to downed phone and power lines, will further isolate and make obtaining assistance more difficult if needed.

Human Services - The loss of usual means of transportation to provide emergency services and the dependence upon back up power systems will be the first of many impacts upon the Human Service Agencies. The lack of reliable communications and personnel to staff and provide services paired with increased demand for services they provide may overwhelm smaller agencies and tax many larger agencies to near exhaustion.

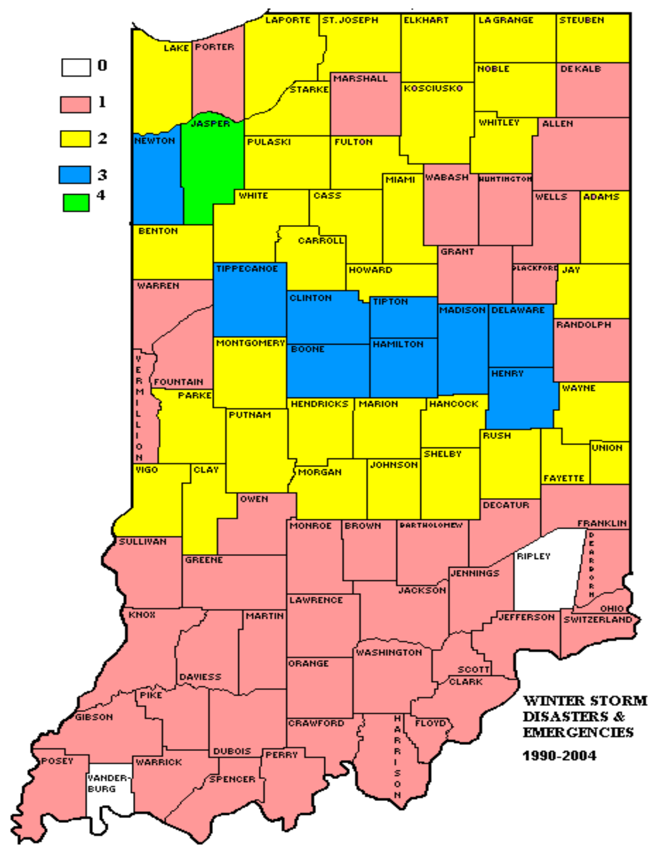
Transportation Exposure - The transportation network will be the first impacted. Snow and ice accumulations will make travel along these systems difficult or impossible. These types of storms do not usually destroy this type of infrastructure, but rather result in temporary effects. The problem is normally debris related. The freeze thaw of winter and its related damage to roads is normal and planned for throughout the state. Transportation is more likely to be affected by cascading events, such as debris from ice storms or flooding from excessive snowmelt.

Other Infrastructure Exposure - The storm of 1991 confirmed that a community's infrastructure is likely to experience the most physical damage. Power and communication equipment is vulnerable to winds, but the addition of ice on the lines quickly renders the community without power or communication. The loss of power may mean that communities and individuals may not have water, since it takes electricity to convey it to the customer. Towns and cities depend upon electricity to pump, treat and deliver water to their citizens.

Economic Exposure - Economically, industry and agriculture can suffer the effects of a winter storm. Both are dependent on transportation. The collapse of structures due to snow loading, loss of man-hours and inability to ship goods, receive material or to receive orders for goods and services will impact the economic community. Historically, Indiana has suffered agriculturally from loss of livestock or crops due to winter storms and cascading events such as flooding.

8. Loss Estimation

Winter Storm Disasters



The loss potential to above-ground infrastructure could be devastating. The lack of past history of frequent severe storms does not provide a large sample of information upon which to base loss estimates. The 1991 storm that brought a declaration for 21 counties in Indiana was by far the largest disaster in recent history. Winter storms in Indiana normally are not long-term recovery programs. These events normally only require emergency snow and debris removal. They can also be deadly due to exposure, fire, carbon monoxide poisoning, and transportation accidents.

The lack of public awareness, preparedness and mitigation will result in increased losses as the population and the dependence upon technology continues. The recovery time to power and communication infrastructure can be improved by the requirement that electric and communications service lines be buried. The lack of heat in residences and the exposure to cold is the greatest threat to people. Public education on the dangers of alternative heating systems, and what to do if caught outside during a storm would reduce the risk to the population. These programs can prevent the state's exposure to loss from these storms from increasing as the population increases.

WINTER STORM DECLARATION EXPENDITURES

DISASTER #	DATE	# OF COUNTIES	EXPENDITURES
DR-899	3/29/91	21	$9,222,104.00
DR-1109	4/2/96	35	$4,130,652.00
DR-1217	5/8/98	8	$5,585,824.00
EM-3135	1/15/99	59	$12,908,434.99
EM-3162	1/24/01	19	$4,797,468.13
EM-3179	1/11/05		$5,793,507.01
EM-3274	3/12/07		$9,057,430.79
		TOTAL	**$51,495,438.92**